Review Paper of PAPR Reduction Technique

PAPR reduction in OFDM

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***Abstract* – In orthogonal frequency division multiplexing (OFDM) system high peak to average power ratio (PAPR) is one of the major technical challenges which bring serious impact on hardware implementation. In this paper reduction technique base on computational complexity, bandwidth expansion, spectral spillage and performance In this paper, PAPR problem is defined and this paper present different PAPR reduction techniques and conclude an overall comparison of these techniques**.

***IndexTerms*- orthogonal frequency division multiplexing (OFDM), Peak to Average Power Ratio (PAPR).**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is the digital multicarrier modulation scheme for high speed communication systems. One of the major problems in OFDM is the occurrence of high Peak to Average Power Ratio (PAPR). Due to high PAPR the signal leads to out-of-band (OBO) distortion and increase in Bit Error Rate (BER). The reduction in PAPR is desirable in order to obtain the power efficiency of the amplifier at the transmitter. OFDM system is implemented in several broadband communication systems like Wireless Local Area Network (WLAN), worldwide interoperability for Microwave Access (WiMax), Digital Video Broadcasting (DVB) and Digital Audio Broadcasting (DAB).

To solve the problem of PAPR many techniques have been proposed by various researchers which include Clipping Companding, Coding , Interleaving , Selective Mapping , Partial Transmit Sequence , Active Constellation Extension . Tone Reservation and Tone Injection .Many PAPR reduction techniques result in performance degradation in terms of BER as compared to original OFDM signal. This paper discusses all the prominent PAPR reduction techniques described above. Section II deals with definition of the OFDM signals and Peak-to-Average Power (PAPR) mathematical expression along with the performance measure to calculate PAPR .Section III describes various PAPR reduction techniques and in section IV conclusion is given.

II. DEFINITION OF OFDM AND PAPR

OFDM is a multicarrier modulation technique, in which the bit stream is divided over several orthogonal subcarriers, each modulated at a low rate. The block diagram of OFDM system is described in figure1.Orthogonality is assured by choosing appropriate frequency spacing between them. The number of sub-carrier is chosen to insure that each sub-channel has a bandwidth less than the channel coherence bandwidth thereby experiencing flat fading.

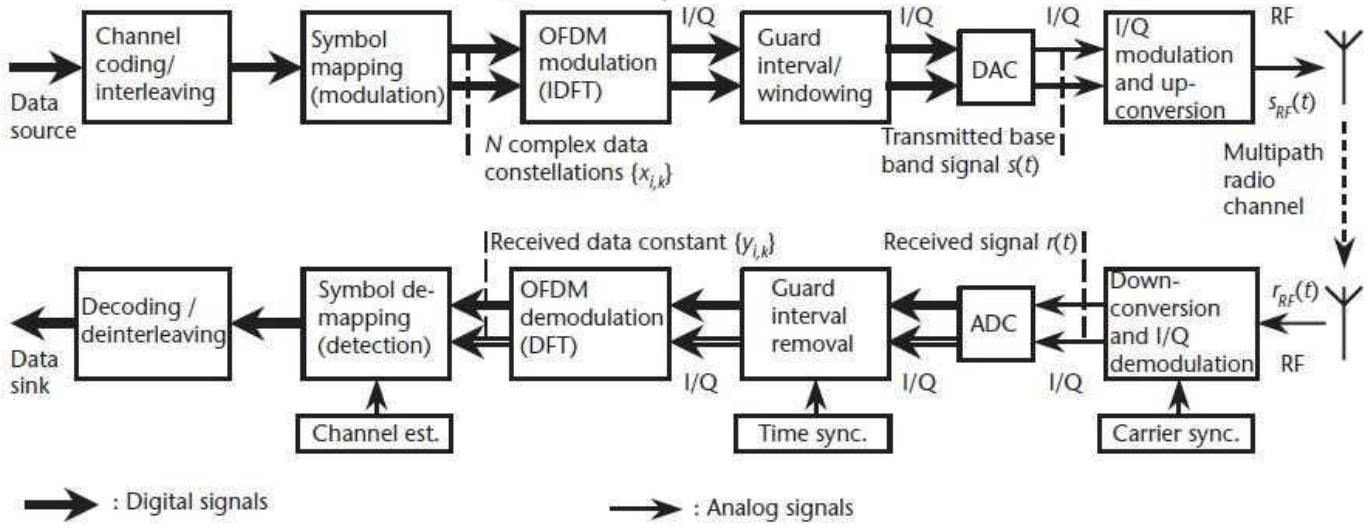

Figure 1: The block diagram of OFDM system

Peak to average power ratio is a signal property that is calculated by dividing the peak power amplitude of the waveform by the RMS value of it, a dimensionless quantity which is expressed in decibels (dB). In digital transmission when the waveform is represented as signal samples, the PAPR is defined as

$$PAPR = \frac{\max(|S[n]|^2)}{E\{|S[n]|^2\}}, \quad 0 \le n \le N-1,$$

Where $S[n]$ represents the signal samples, $\max(|S[n]|2)$ denotes the maximum instantaneous power and $E\{|S[n]|2\}$ is the average power of the signal, and $E\{.\}$ is the expected value operation.

III. . PAPR REDUCTION TECHNIQUE

A] Signal Scrambling Technique

- Block Coding Technique
- Sub Block Coding Technique
- Selective Mapping (SLM)
- Partial Transmit Sequence (PTS)
- Interleaving Technique
- Tone Reservation (TR)
- Tone Injection (TI)

B] Signal Distortion Technique

- Peak Windowing
- Clipping and Filtering
- Envelope Scaling

A] Signal Scrambling Technique

Block coding technique

Main objective of this technique is to reduce PAPR using different block coding & set of code words. This scheme is widely used to reduce the peak to mean envelope power ratio. While selection of the suitable codeword many things must be considered like M-ray phase modulation scheme, any type of coding rate, suitable for encoding –decoding & also main thing is that error correction /error decoding.

Sub block coding techniques

To reduce PAPR more than 3db sub block coding technique is widely used. But this can be achieved at ¾ code rate. This techniques based on ¾ code rate systematically with added last odd parity checking bit to develop lowest peak envelope power. This coding scheme is termed as systematic odd parity checking coding (SOPC). Large reduction in PAPR can be obtained by the divided large frame into sub block encoded with SOPC.

Selective Mapping (SLM)

In the conventional SLM scheme, M statistically independent phase sequences are generated, and then multiplied by the frequency-domain data sequence $\mathbf{X}$ to produce the M independent candidate signals. Through IFFT transformations, the candidate signal with the lowest PAPR is selected for transmission, as shown in Fig. 1. Let the frequency-domain candidate signal $\mathbf{S}0 = \mathbf{X}$ be the original data vector and the corresponding time-domain signal be $\mathbf{s}0 = \mathbf{F}\text{-}1\mathbf{S}0 = \mathbf{F}\text{-}1\mathbf{X}$, where $\mathbf{F}$-1 represents the matrix of IFFT. We denote the random-generated phase vector as

$$\gamma_m = \left[b_0^{(m)}, b_1^{(m)}, \cdots, b_{N-1}^{(m)} \right]^T, \text{ for } m = 0, \ldots, M-1$$

and the frequency-domain candidate signals as

$$\mathbf{S}_m = \mathbf{R}_m \mathbf{X} = \left[b_0^{(m)} X_0, b_1^{(m)} X_1, \cdots, b_{N-1}^{(m)} X_{N-1} \right]^T,$$

for $m = 0, \ldots, M-1$, where

$$\mathbf{R}_m = \begin{bmatrix} b_0^{(m)} & & \mathbf{0} \\ & b_1^{(m)} & \\ & & \ddots \\ \mathbf{0} & & b_{N-1}^{(m)} \end{bmatrix}$$

is referred to as the phase rotation matrix corresponding to the phase rotation vector γ_m. Correspondingly, the time-domain candidate signals are $\mathbf{S}m = \mathbf{F}\text{-}1\mathbf{S}m$, for $m = 0, \ldots, M - 1$. In conventional SLM, the transmitter requires performing M IFFT operations in order to generate the M time-domain candidate signals, leading to a very high computational complexity.

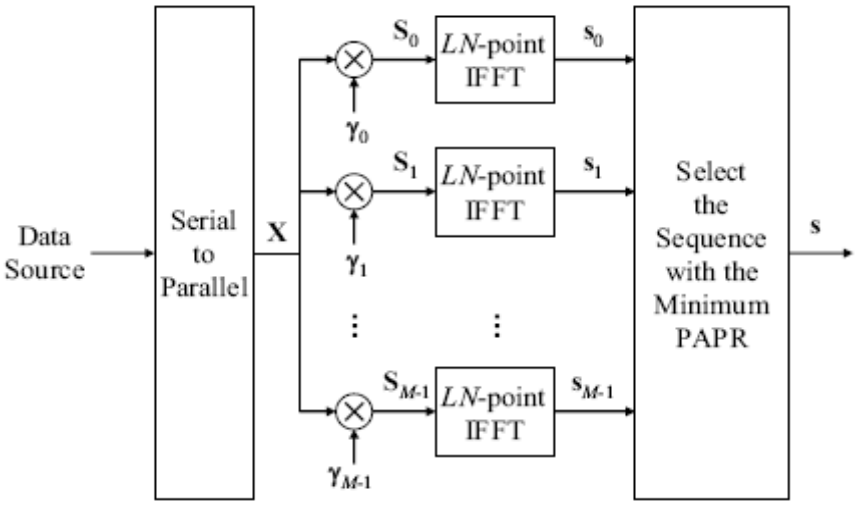

Figure 2: The block diagram of SLM system

Partial Transmit Sequence (PTS)

Block diagram of PTS is shown in Figure . In the PTS technique, an input data block of N symbols is partitioned into disjoint sub locks and then the signal is transmitted. Another factor that may affect the PAPR reduction performance in PTS is the sub block partitioning, which is the method of division of the subcarriers into multiple disjoint sub blocks .There are three kinds of sub block partitioning schemes :adjacent, Interleaved and pseudo-random partitioning. The PTS technique works with an arbitrary number of subcarriers and any modulation scheme. Advantage is that works with an arbitrary number of subcarriers any modulation scheme. But, this scheme includes complexity and side information like

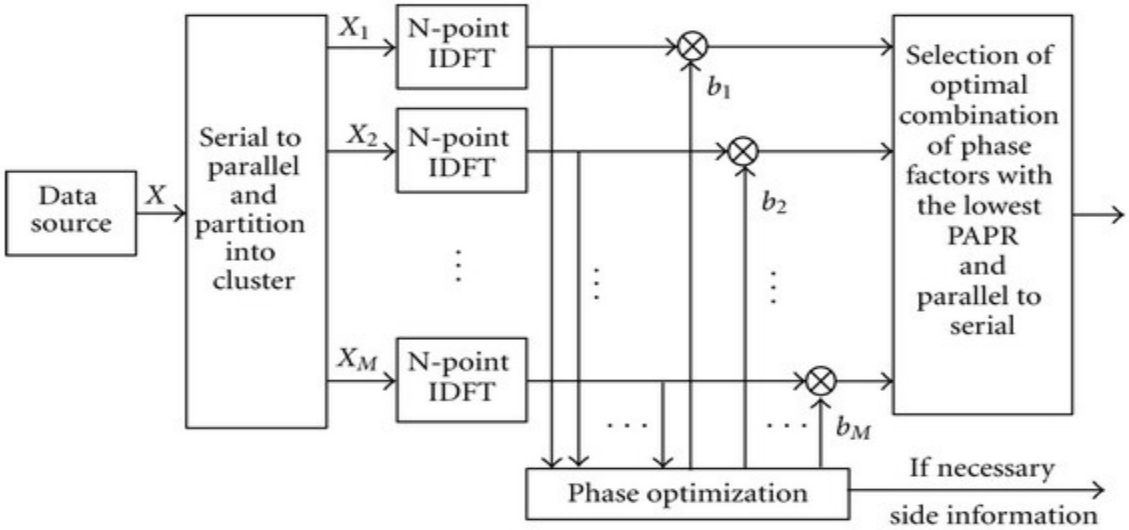

Figure3: Block diagram PTS system

Interleaving Technique

In this technique highly correlated data frame .in this adaptive technique also reduces the complexity. Adaptive interleaving is to establish an early terminating threshold. So the searching process is terminated when the value of PAPR reaches below the threshold value so, these low threshold force the AIL to search for all interleaving sequence. This technique is less complex than PTS.

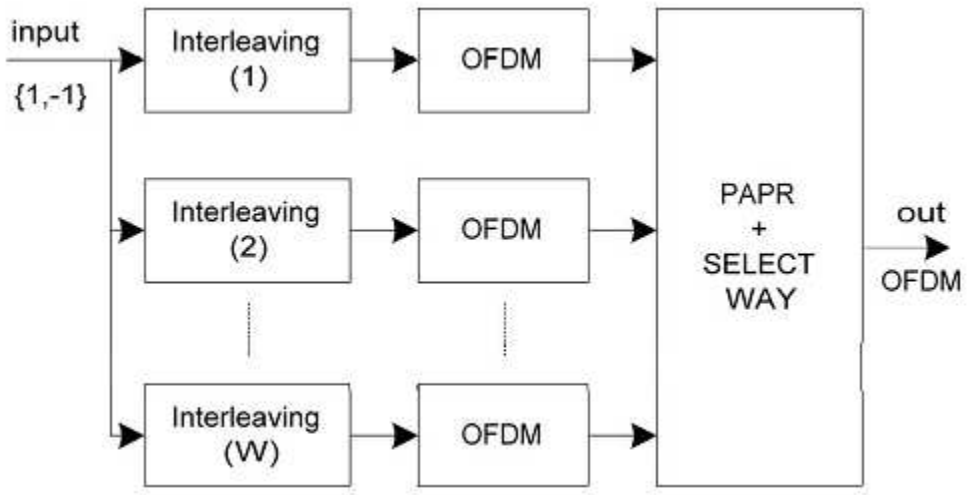

Figure4: Block diagram of interleaving Technique

Tone Reservation (TR) and Tone Injection (TI):

power and same order of computational cost in the tone Reservation method. In this technique some set of tones are reserved called as peak reduction carriers and these are added to the data signal to isolate energy to cancel large peaks these tones does not bear any information and are orthogonal to each other while Tone Injection technique reduces the PAPR without reducing the data rate similar to ACE some constellation points are extended outside the signal constellation but in a different way than in ACE. Extra flexibility is provided by mapping points of original constellation into extended constellation and then by combining the data signal and Peak reduction carrier so generated. By maximizing signal-to-distortion ratio error probability can be increased for the same transmit

B] Signal Distortion Technique

Peak Windowing

With this technique it is possible to remove larger peaks at the rate of a little amount of interference when large peaks a rise in frequently. It mitigates PAPR at cost of increases BER (bit-error-rate) and out-of-bands radiation. It provides better PAPR mitigation with better spectral properties. In this method multiply large signal peak with a specific window such as Gaussian shaped window, Kaiser, cosine, and hamming window which results a spectrum of convolution of original OFDM spectrum with spectrum of window. The window size should be narrow otherwise it affects number of signal sample which cause increasing BER. PAPR level will decrease to 4db with this technique from number of independent sub carrier. SNR limited to 0.3db due the signal distortion. Back off *Pmax* of about 5.5 dB require to keep in band spectral density to at-least 30db below.

Clipping and Filtering

The simplest technique of PAPR reduction is clipping whose fundamental process to clip the part of signal which is out of allowed region with high peak . Clipping is expressed as

$$C(X)=\begin{cases} x & , \ |x| \le A \\ A & , \ |x| > A \end{cases}$$

A = Positive real number represent clip level

This is the simple algorithm to mitigate PAPR by removing the signal component that exceeds some unchanging amplitude called clip level. It is a non-linear process which causes in-band noise, which demotes performance of BER and out of band noise which further reduces the spectral efficiency. Filtering after clipping can demote out of band radiation but cause peak re-growth which may exceed clip level. To avoid peak re-growth iterative clipping and frequency domain filtering can be used.

Envelop Scaling

Objective of this algorithm is to mitigate PAPR by scaling. Input envelope for few subcarrier before IFFT operation. Here 256 subcarriers with QPSK modulation technique are used to make sure envelope for all subcarrier are equal. According to algorithm input envelope in some sub-carrier is scaled to attain the smallest amount of PAPR at IFFT output. Thus, at receiver there is no need of side information for decoding purpose. PAPR reduces to 4db with same algorithm. If QAM is used number of sub-carrier will large then need to send excessive side information otherwise BER demote in large amount.

IV. CONCLUSION

OFDM is a very attractive technique for wireless communications due to its spectrum efficiency and channel robustness. One of the serious drawbacks of OFDM systems is that the composite transmit signal can exhibit a very high PAPR when the input sequences are highly correlated. In this paper, several important aspects are described as well as mathematical analysis is provided, including the distribution of the PAPR used in OFDM systems. Three typical signal scrambling and distortion techniques, SLM, PTS and Companding are investigated to reduce PAPR, all of which have the potential to provide substantial reduction in PAPR. Proposed Companding method performs better than PTS method and SLM method in reducing PAPR.

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